SOUND TRANSIT

HCT Planning

Sound Transit 2 Planning

Sustainability Assessment of Sound Transit 2 Plan

Assessment of Greenhouse Gas Emissions; Energy Security Implications; and Mobility, Land Use, and Other Potential Benefits in the Central Puget Sound Region

Prepared for:
Sound Transit

Prepared by:
Parsons Brinckerhoff
and
Victoria Transport Policy Institute
with
Introduction by Sound Transit

FINAL

August 5, 2008

Table of Contents

1. Summary of Findings 1
1.1 Greenhouse Gas Assessment 1
1.2 Energy Security 1
1.3 Mobility, Land Use, and Transportation 2
2. Introduction 2
2.1 Background of the Sound Transit 2 Plan 2
2.2 Sustainability Assessment 3
3. Greenhouse Gas Assessment 3
3.1 Greenhouse Gases 3
3.2 Methodology and Impacts 5
3.3 Summary and Discussion of Impacts 11
4. Energy Security Implications 14
4.1 Energy Source for ST2 14
4.2 Becoming Rapidly More Dependent on Imported Oil 14
4.3 Energy Security Risks 17
4.4 Transit Agency Energy Security Risks 20
4.5 Gasoline and Diesel Cost Savings from VMT Reductions 20
4.6 Conclusions from Energy Security Analysis 21
5. Mobility, Land Use, and Other Potential Benefits 22
5.1 Background 22
5.2 Travel Demands Shifts 23
5.3 Relationship between Transit, VMT and Supportive Strategies 24
5.4 Transportation Improvement Strategies 26
5.5 Sound Transit Supportive Programs 29
6. References 31
7. Appendix – VMT Reduction Estimation Framework 33

List of Figures

Figure 3.1 - The Greenhouse Effect... 4
Figure 3.2 - GHG Emissions by Sector, 2005, US and Washington State 5
Figure 3.3 – Greenhouse Gas Analysis Approach... 6
Figure 4.1 - U.S. Crude Oil Production Has Been in Decline for Several Decades......... 15
Figure 4.2 - Alaskan Oil Production, Washington State’s Primary Source, is in Decline 15
Figure 4.3 - Oil Imports on the Rise on the West Coast... 16
Figure 4.4 -U.S. West Coast Oil Imports, Non-OPEC and OPEC 17
Figure 4.5 – Schematic of Major Pipeline Movements 19
Figure 5.1 – Work Trip Mode Share by City.. 24
Figure 5.2 - Per Capita Annual Vehicle Miles Traveled (VMT)...................................... 25
Figure 5.3 - Portland’s Vehicle Travel Trends 26

List of Tables

Table 3.1 – Vehicle Mix 8
Table 3.2 – Annual CO_2e Emission Burdens from Roadway VMT.................................. 9
Table 3.3 – Annual CO_2e Emission Burdens from Sound Transit Bus VMT 9
Table 3.4 – Annual CO_2e Emission Burdens from Electric LRT VMT (assuming current energy profile)... 10
Table 3.5 – Annual CO_2e Emission Burdens from Electric LRT VMT with Carbon-Free Profile... 10
Table 3.6 – Annual CO_2e Emission Burdens from Commuter Rail VMT 11
Table 3.7 – CO_2e Summary Emission Burden Assuming Current LRT Energy Profile and Carbon Free Electric Profile 13
Table 4.1. – Fuel Mix for Power Generation, 2007 14
Table 5.1 - Trends Affecting Travel Demands 23
Table 5.2 – Potential Travel Impacts of Transport Demand Management Strategies...... 28
Table 5.3 - Transportation Service Enhancement Programs 29
Table 5.4 - Transportation Enhancement - Implementation Responsibilities.................. 30
Table 7.1 – Example of Collaborative Framework to Estimate Potential VMT Reductions from Various Strategies 34

Executive Summary

Sound Transit is committed to the development of a sustainable high capacity transit system for the central Puget Sound region. The agency is nearly finished with the implementation of Sound Move, the first phase of the regional system, and in July 2008, the Sound Transit Board adopted the second phase of that system, Sound Transit 2 or the Mass Transit Expansion plan. The Mass Transit Expansion plan builds on the popular regional bus, commuter rail and light rail services implemented as part of Sound Move, and in November 2008, the plan will be presented to voters in the Sound Transit district for financing approval.

To inform policy makers and the public on the sustainability of the Mass Transit Expansion plan, Sound Transit has prepared this assessment of the plan's effect on greenhouse gas emissions, energy security, and mobility, land use and other benefits. The assessment also reviews other strategies enabled by the Mass Transit Expansion plan that will further reduce emissions. The benefits of these strategies are already being demonstrated through Sound Move projects and services and would be exponentially enhanced by implementing the next phase of the regional high capacity transit system.

Evaluating greenhouse gas emissions and energy security implications of a transit plan is a nascent discipline in the climate change arena, and one that is rapidly evolving. Numbers only tell part of the story, especially when it comes to quantifying the benefits of the plan. Despite these challenges, Sound Transit has decided to be in the forefront by preparing this assessment.

As this sustainability assessment shows, the Mass Transit Expansion plan would result in absolute reductions in car trips, vehicle miles traveled, energy consumption, and emissions of greenhouse gases and other pollutants, and would serve as a catalyst for other strategies that can further reduce vehicle trips and greenhouse gas levels. The plan would give residents of the region more tools for sustainable patterns of living, working and commuting by promoting the development of vibrant and walkable mixed-use communities where people are less reliant on cars. By implementing the Mass Transit Expansion plan, the region is well-positioned to make significant progress in accomplishing the Governor's Climate Action agenda and the Western Climate Initiative targets.

Key findings include:

- The plan reduces greenhouse gas emissions by 100,000-180,000 metric tons annually, the most significant reduction possible under transportation policy options actively being considered in the region. To give those numbers some context, a reduction of 140,000 (the midpoint of the range) metric tons a year is equivalent to 48,000 fewer tons of landfill waste or 1,000 acres of forest land preserved each year.

- The ridership model from which these numbers are derived is constrained by conservative federal ridership modeling requirements. There is a high probability that the system ridership and therefore emission reductions would be substantially greater. Even before the recent jump in fuel prices, actual ridership on Sound Transit's regional bus, commuter rail and light rail have exceeded forecasts.

- Sound Transit's unique offering of grade-separated and exclusive rights-of-way rail services give more commuters a congestion free commute, thereby attracting new riders to the region's transit system. By connecting more places for more people, the plan ensures that transit ridership across the region will grow and carbon emissions will be reduced.

- In cities across the county and around the world, the availability of transit is a catalyst for the creation of compact, livable communities that reduce reliance on cars. The benefits of more densely developed communities, pedestrian and bicycling improvements, and rising property values are not included in the quantitative results of the assessment. Based on national data, the assessment indicates that the benefits of these synergistic strategies would generate an estimated 5-30% in additional reductions in vehicle miles traveled and associated emissions.

- In assessing the energy sustainability of a key feature of the Mass Transit Expansion plan -- the expansion of regional light rail system by 36 miles -- the assessment shows that because light rail runs on non-carbon hydroelectric power, expanding it would result in a virtually zero-emissions transit trip.

- In assessing the energy security benefits of the plan, the report shows the benefits of an increased diversification of non-petroleum based energy for transportation and the benefits of not sending dollars out of the State of Washington to pay for oil or fuel. These are significant factors and bear directly on the regional economy, security and climate.

- The Mass Transit Expansion plan also sets the table for the region to implement other transportation policies for a sustainable regional transportation system. With the Mass Transit system in place, the region can derive greater benefits from road and parking pricing, transit lanes and other priority lane features. For these kinds of policies, the assessment (Chapter 5) demonstrates typical, additional reductions in vehicle miles traveled between 5-30% depending on the strategies being implemented.

Sound Transit is in a unique position to continue the implementation of a sustainable transportation vision for the Puget Sound region and to help the state of Washington meet the challenge of global climate change. This sustainability assessment demonstrates that the Mass Transit Expansion plan reduces carbon emissions, vehicle trips, and vehicle miles traveled, and serves as a catalyst for a truly sustainable transportation future.

1. Summary of Findings

The Sound Transit Board approved placing a Sound Transit 2 (ST2) plan on the ballot in November 2008. The plan includes approximately 34 miles of light rail transit supplementing the 19 miles of rail nearing completion that was funded by Sound Move. Sound Transit is committed to developing a sustainable transportation system, and being a positive influence in the future sustainability of the region. As part of Sound Transit's continuing commitment to sustainability, Sound Transit is conducting this sustainability assessment of the ST2 plan. This document evaluates the greenhouse gas emissions impacts due to ST2 operation; energy security implications; and mobility, land use, and other potential benefits of the plan.

The analysis then continues with the identification of additional strategies that can further reduce future greenhouse gas levels when compared to the future baseline condition. Since travel behavior is so closely linked with other policies, ordinances, and programs, a menu of optional strategies have been identified that would leverage the enhanced rail service included in the ST2 program. Each of these programs has a potential to further reduce vehicle trips and the associated greenhouse gas emissions. However, since many of these strategies lie outside of Sound Transit's authority (land use policy for example) this document does not attempt to define a recommended suite of strategies. Rather, a methodology for accurately assessing the impact of a set of strategies is presented.

1.1 Greenhouse Gas Assessment

In 2030, the ST2 build alternative is predicted to reduce overall regional CO_2e emissions by approximately 362 metric tons daily, or 99,552 metric tons annually using current electric power fuel mix assumptions. Under a potential future scenario in which all electricity is generated using non-carbon emitting sources, the CO_2e emissions reduction is about 585 metric tons daily or 178,334 metric tons annually. To estimate the GHG impacts of the plan, transportation modeling estimates of VMT by mode and vehicle type (i.e. cars, LRT, buses, commuter rail) was converted into energy consumption. Then depending on the energy source and vehicle efficiency, the VMT from various modes is converted into CO_2 equivalents (CO_2e).

1.2 Energy Security

This analysis has found several energy security benefits that could result from expanding high capacity light rail transit in the region. These include:

- Increasing the diversification of non-petroleum based energy sources for transportation.
- Retaining more money within the state rather than being exported out of the state or country.

The Puget Sound region is heavily reliant upon petroleum for its transportation systems, and the U.S. west coast is rapidly increasing its need for oil imports as Alaskan oil production continues to decline. There are several security risks to this dependence on oil, and increasing dependence on imported oil. These risks include geopolitical disruptions, inadequate petroleum refining or processing capabilities, peak oil, natural disasters, or terrorist attacks on critical energy infrastructure.

The Puget Sound region may be particularly vulnerable to oil or fuel supply disruptions because the region is not well-connected to domestic energy infrastructure in other areas of the country, so there is limited flexibility for the U.S. energy industry to respond to short-term supply disruptions on the west coast.

In addition, the region currently spends about $4.7 billion a year, at current fuel prices, on gasoline and diesel for light duty vehicles. Expansion of light rail would reduce regional gasoline/diesel expenditures by about $41 million per year.

1.3 Mobility, Land Use, and Transportation

The twentieth century was the period of automobile ascendency, during which private motor vehicle travel grew from almost nothing to become the dominant form of transport in most communities. During that period it made sense to devote considerable resources to building roads and parking facilities. The automobile-oriented transportation system is now mature. Further expansion provides little marginal benefit, while the economic, social and environmental costs of automobile travel are increasing. The 21st Century will be a period of increased transport system diversity. Automobile travel will not disappear, but much of the growth in travel demand can be satisfied by alternative modes, and management strategies, provided they are high quality and well integrated.

Responding to changing demands requires improving the performance, convenience, comfort and security of alternative modes. Many of our current policies and planning practices are still oriented primarily toward automobile transportation, and so are unresponsive to current and future demands.

Sound Transit is in a unique position to identify and implement a sustainable transportation vision for the Puget Sound region. As a regional planning agency and service provider it is responsible for the major regional transport projects which tend to be costly but most beneficial and sustainable. The success of these projects depends on cooperation among many jurisdictions and organizations. More comprehensive and integrated evaluation, which leads to more optimal planning decisions, can provide large direct and indirect benefits to citizens of the Central Puget Sound region.

2. Introduction

2.1 Background of the Sound Transit 2 Plan

In 2009, Sound Transit will open light rail transit between the Seattle Tacoma International Airport and downtown Seattle, and expand the system from downtown Seattle to the University of Washington in 2016. The Sound Transit Board has approved placing a Sound Transit 2 (ST2) plan on the ballot in November 2008. The ST2 plan that will be on the ballot includes the following components:

- 34 additional miles of LRT

- North from University of Washington to Northgate, Shoreline and Lynnwood
  - East from downtown Seattle across Interstate 90 to Mercer Island, Bellevue, Overlake Hospital and Redmond's Overlake Transit Center
  - South from Sea-Tac Airport to Highline Community College and Federal Way at South 272nd Street
- Streetcar connector service serving Seattle's International District, First Hill and Capitol Hill
- Extension of Tacoma Link beyond the downtown Tacoma area.
- Increased Sounder trips, extended platforms and longer trains
- Expanded Regional Express bus service

2.2 Sustainability Assessment

Sound Transit is committed to developing a sustainable transportation system, and being a positive influence in the future sustainability of the region. In 2007, the Sound Transit Board adopted a Sustainability Initiative integrating sustainable business practices throughout the agency. Since then, agency staff has been implementing that direction. Sound Transit's plan for addressing climate change includes measurable targets related to fuels, vehicles, and emissions; ecosystem protection; green procurement; recycling and waste prevention; energy and water conservation; sustainable design and building; and education and awareness. The agency's Environmental and Sustainability Management System (ESMS) was developed and implemented to manage this effort. In addition, Sound Transit recently achieved ISO 14001 compliance for its environmental management system. To meet the requirements, an organization must put in place management tools enabling it to identify and control the environmental impact of its activities, products or services and to improve its environmental performance continually.

As part of Sound Transit's continuing commitment to sustainability, Sound Transit is conducting a sustainability assessment of the ST2 plan. This assessment evaluates the greenhouse gas emissions impacts due to ST2 operation; energy security implications; and mobility, land use, and other potential benefits of the plan.[1]

3. Greenhouse Gas Assessment

3.1 Greenhouse Gases

Gases that trap heat in the atmosphere are often referred to as greenhouse gases (GHG). GHG are necessary to life as we know it because they keep the planet's surface warmer than it otherwise would be. This is referred to as the Greenhouse Effect (Figure 3.1). As concentrations of greenhouse gases are increasing, however, the Earth's temperature is increasing.

According to National Oceanic and Atmospheric Administration (NOAA) and National Aeronautics and Space Administration (NASA) data, the Earth's average surface temperature has

[1] The greenhouse gas emissions and energy security assessments were conducted by Parsons Brinckerhoff, while the assessment of mobility, land use, and other benefits was conducted by the Victoria Transport Policy Institute.

increased by about 1.2 to 1.4ºF in the last 100 years. Eleven of the last twelve years rank among the twelve warmest years on record (since 1850), with the warmest two years being 1998 and 2005. Most of the warming in recent decades is very likely the result of GHG emissions generated by human activities. Other aspects of the climate such as rainfall patterns, snow and ice cover, and sea level are also changing as a result of global warming.

Some GHG, such as carbon dioxide, occur naturally and are emitted to the atmosphere through natural processes and human activities. Other GHG gases, such as fluorinated gases, are created and emitted solely through human activities.

The principal GHG that enter the atmosphere because of human activities are described below.

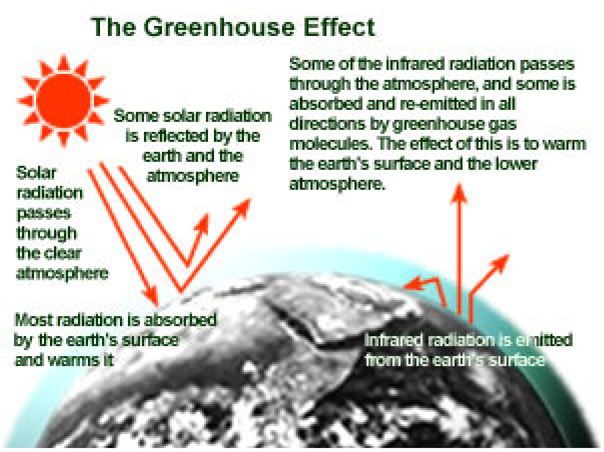
Carbon Dioxide (CO_2). Carbon dioxide enters the atmosphere through the burning of fossil fuels (oil, natural gas, and coal), solid waste, trees and wood products, and also as a result of other chemical reactions (e.g., manufacture of cement). Carbon dioxide is also removed from the atmosphere (or "sequestered") when it is absorbed by plants as part of the biological carbon cycle.

Methane (CH_4). Methane is emitted during the production and transport of coal, natural gas, and oil. Methane emissions also result from livestock and other agricultural practices and by the decay of organic waste in municipal solid waste landfills.

Nitrous Oxide (N_2O). Nitrous oxide is emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste.

Fluorinated Gases. Hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride are synthetic, powerful greenhouse gases that are emitted from a variety of industrial processes. These gases are typically emitted in small quantities, but because they are potent greenhouse gases, they are sometimes referred to as High Global Warming Potential gases.

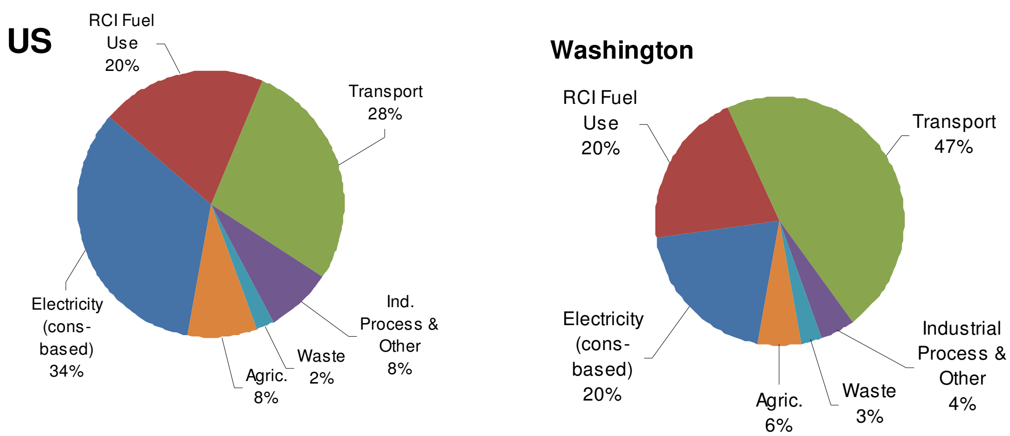
Figure 3.1 - The Greenhouse Effect



Source: http://www.epa.gov/climatechange/science/index.html

National estimates show that the transportation sector (including on-road, construction, airplanes, and boats) accounts for almost 30 percent of total domestic CO_2 emissions.[2] However, in Washington State, transportation accounts for nearly half of greenhouse gas emissions because the state relies heavily on hydropower for electricity generation, unlike other states that rely on fossil fuels such as coal, petroleum, and natural gas to generate electricity (Figure 3.2). The next largest contributors to total gross GHG emissions in Washington are fossil fuel combustion in the residential, commercial, and industrial (RCI) sectors at 20 percent and in electricity generation facilities, also 20 percent.

Figure 3.2 - GHG Emissions by Sector, 2005, US and Washington State



Source: Washington Climate Advisory Team, 2008

GHG differ in their ability to trap heat. For example, one ton of CO_2 emissions have a different effect than one ton of emissions of methane. To compare emissions of different GHGs, inventory compilers use a weighting factor called a "Global Warming Potential" or "GWP." To use a GWP, the heat-trapping ability of one metric ton (1,000 kilograms) of CO_2 is taken as the standard, and emissions are expressed in terms of CO_2 equivalent (CO_2e), but can also be expressed in terms of carbon equivalent.

3.2 Methodology and Impacts

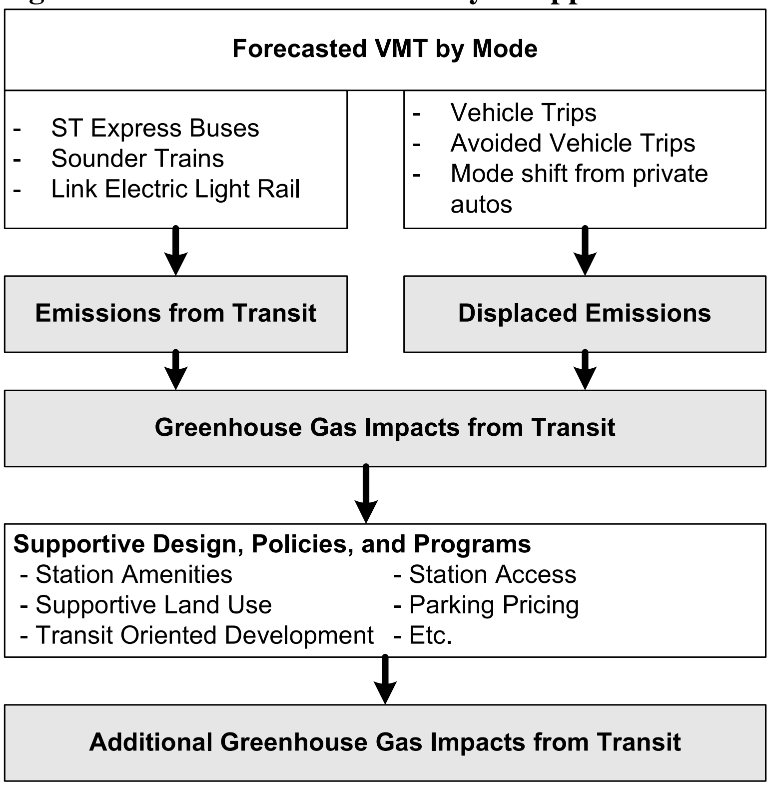
For GHG estimates for transportation projects, analyses are based on fossil fuel consumption, where CO_2 is the predominant greenhouse gas emitted along with CH_4 and N_2O. This analysis focuses on these three greenhouse gases, with the emission burdens of each alternative expressed in terms of CO_2e. GWPs of 21 and 310 were applied to CH_4 and N_2O, respectively, in the calculation of overall CO_2e levels.[3]

A quantitative analysis was conducted to estimate changes in GHG emissions resulting from the operation of the project. It is anticipated that the project will affect roadway, bus, light rail (LRT) and commuter rail vehicle miles traveled (VMT). Each one of these elements was individually analyzed, and the resulting emission burdens were combined, resulting in an overall

[2] This percentage is based on 2004 data from the International Energy Administration and is consistent with 1996 guidelines on greenhouse gas emissions calculations issued by the Intergovernmental Panel on Climate Change (IPCC).
[3] The Climate Registry, General Reporting Protocol, March 2008.

GHG emission burden estimate for each project alternative. An overview of the analysis approach is presented in Figure 3.3.

Figure 3.3 – Greenhouse Gas Analysis Approach



3.2.1 Roadway VMT

The project is anticipated to affect VMT on roadways within the study area. To determine how changes in VMT will affect GHG generated on roadways within the study area, a quantitative analysis was conducted using vehicle emission rates and overall projected VMT. Emission rates are based on fuel consumption rates, generally expressed in terms of miles per gallon (mpg) or British thermal units (Btu) per mile. There are two main sources of energy information for roadway VMT. They are the U.S. Department of Energy (USDOT) and the U.S. Environmental Protection Agency (USEPA).

The US Department of Energy (DOE) releases an annual "Transportation Energy Data Book" which contains energy usage information for various transportation modes. The current version of the Transportation Energy Data Book is edition 27 released on June 30, 2008. The factors given in this data source represent US average rates for the current year.

Emission rate factors are also available through the US Environmental Protection Agency's (EPA) MOBILE6: Mobile Source Emission Factor Program. As stated in this program's user's manual:

"These emissions are estimated in a very simple fashion based on fuel economy performance estimates built into the model or supplied by the user…..emission estimates are not adjusted for speed, temperature, fuel content, or the effects of vehicle inspection maintenance programs. This means that MOBILE6 cannot be used to model the effects on CO_2 emissions by varying these parameters. It also means that these CO_2 emission estimates should only be used to model areas and time periods which are large enough to reasonably assume that variation in these parameters does not have a significant effect"

MOBILE6 emissions do reflect area specific vehicle mix and varying fuel efficiency rates, which allow the emissions factors to be more specific to the study area than the values provided in the DOE source. Therefore, CO_2 emission factors from MOBILE6 were used in this analysis. Emission factors for N_2O and CH_4, which represent less than 0.4 percent of the total CO_2e emission factor, were based on emission factors obtained from the Climate Registry Direct Emissions from Mobile Combustion, using an appropriate area specific vehicle mix.

The vehicle mix used for this analysis, shown in Table 3.1, reflects the 2005 fleet for the area. The vehicle mix was kept at the 2005 level because the current projections in MOBILE6 reflect a continued increase in light-duty truck sales, representing 68 percent of the vehicle sales in 2020. Given the recent increase in fuel prices and the change in vehicle purchase patterns, this increase was considered unreasonable.[4]

[4] CARB - "Comparison of Greenhouse Gas Reductions for the United States and Canada under U.S. Café standards and California Air Resources Board Greenhouse Gas Regulations", February, 2008.

Table 3.1 – Vehicle Mix

Vehicle Type	% of Vehicle Mix
Gasoline Passenger	41%
Gasoline Light Truck	46%
Gasoline Heavy Truck	4%
Diesel Passenger Vehicle	<1%
Diesel Light Truck	<1%
Diesel Heavy Truck	8%
Motorcycle	<1%
Total	100%

To represent the future scenarios, fuel economy of the future fleet, which is directly related to the Corporate Average Fuel Economy (CAFE), must be taken into account. CAFE is the sales-weighted average fuel economy, expressed in miles per gallon (mpg), of a manufacturer's fleet of passenger cars or light trucks with a gross vehicle weight rating (GVWR) of 8,500 lbs. or less, manufactured for sale in the United States, for any given model year. There are currently two pieces of legislation regarding future fuel economy. The first is the Energy Independence and Security Act of 2007 (Public Law 110-140)[5]. This law mandates improve CAFÉ standards, requiring a fleetwide average of 35 mpg for light duty vehicles sold in 2020 and beyond. The second piece of legislation is California Air Resources Board's (ARB) waiver request to EPA to enforce the state's motor vehicle greenhouse gas emissions rules, known as AB1493 or the Pavley Bill. The Pavley Bill does not directly equate to vehicle fuel economy, but rather it requires GHG emissions to be reduced. Twelve other states including Washington have adopted the Pavley Bill. On December 19, 2007, the EPA announced the decision that they were denying ARB's request for a waiver for Pavley. As the Pavley bill is currently not enforceable, the Federal requirements in the Energy Independence and Security Act of 2007 were applied to address the future fleet's fuel economy in this analysis.

To account for the change in fuel economy, MOBILE6 has an optional MPG estimate command that allows the user to provide their own vehicle fuel economy performance estimates by vehicle class and model year. The effects of improved vehicle fuel economy performance can be modeled by modifying this file. To model the revised CAFÉ standards, it was assumed that the standards would be phased in using a steady proportional increase of 3.44 percent per year in both the fuel economy of passenger cars and light trucks, until the final standard of 35 mpg is reached for 2020 model year vehicles. As there is no current legislation to improve fuel economy past 2020, no further model year improvements in fuel economy were modeled past 2020.

Applying the emissions factors derived from MOBILE6 and from the Climate Registry, the CO_2e pollutant burdens resulting from roadway VMT have been estimated and are presented in Table 3.2.

[5] http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=110_cong_public_laws&docid=f:publ140.110

Table 3.2 – Annual CO_2e Emission Burdens from Roadway VMT

Mode	No Build 2030	2030 With ST2 Plan
Roadways		
Daily VMT	99,398,539	98,536,539
Total CO_2e (Metric tons)	45,485	45,091
% Change from No Build	NA	-0.87%

3.2.2 Sound Transit Bus VMT

The project is anticipated to affect Sound Transit Bus VMT on roadways within the study area. To determine how changes in VMT will affect GHG generated on roadways within the study area, a quantitative analysis based on vehicle emission rates was conducted. A mpg rate of 4.1 for diesel transit buses, supplied from King Country Metro to the East Link DEIS project, was applied to this analysis, reflecting actual fleet fuel consumption. This value was used in this analysis. By dividing the VMT of the buses by the fuel efficiency of the buses in terms of mpg, the quantity of fuel used was derived. By then applying CO_2e emissions rates in terms of CO_2e/gallon of fuel, the amounts of CO_2e generated by Sound Transit Bus VMT were determined. These values are shown in Table 3.3.

Table 3.3 – Annual CO_2e Emission Burdens from Sound Transit Bus VMT

Mode	No Build 2030	2030 With ST2 Plan
Sound Transit Buses		
Daily VMT	50,420	42,427
Total CO_2e (Metric tons)	125	105
% Change from No Build	-	-15.85%

3.2.3 Light Rail Transit VMT

Light Rail Transit (LRT) VMT is also anticipated to be affected by the project. To determine how changes in LRT VMT will affect GHG generated on roadways within the study area, a quantitative analysis based on power requirements was conducted. An LRT system is estimated to require 85,747 btu/mile (APTA Transportation Fact Book, 2007 Data). By multiplying the VMT by this power requirement estimate, the overall power requirement for LRT propulsion was estimated. Since the LRT system power comes from the local grid system, an emission factor based on the Washington State Energy profile, as reflected in the DOE's Energy Information Administration data base, was applied. This reflects a 2002 mix of over 90 percent renewable or carbon-free sources (hydroelectric, wind and nuclear). By applying the DOE emission factor to the Btu requirements for the LRT, the emissions generated by the power requirements of the LRT were estimated and are shown in Table 3.4.

Table 3.4 – Annual CO_2e Emission Burdens from Electric LRT VMT (assuming current energy profile)

	No Build 2030	2030 With ST2 Plan - Current Energy Profile
LRT		
LRT Average Daily VMT	25,701	92,587
LRT CO_2e Metric tons	71.7	258
% Change from No Build	-	261.86%

Through Resolution 30359 of the Seattle City Legislation, Seattle City Light has developed a strategy for meeting the goal of zero net greenhouse gas emissions and establishing specific greenhouse gas mitigation targets and timelines. In addition, RCW 19.285 – Energy Independence Act, requires large utilities in the state to obtain fifteen percent of their electricity from new renewable resources such as solar and wind by 2020 and undertake cost-effective energy conservation. If Puget Sound Energy and Snohomish County PUD should follow Seattle City Light's lead and adopt and meet a goal of zero net greenhouse gas emissions, the resultant CO_2e emission burdens for LRT due to power generation would be zero, as shown in Table 3.5. This could also represent a future potential scenario of 100 percent carbon-free power generation.

Table 3.5 – Annual CO_2e Emission Burdens from Electric LRT VMT with Carbon-Free Profile[6]

	No Build 2030	2030 With ST2 Plan– Carbon Free Energy Profile
LRT		
LRT Average Daily VMT	25,701	92,587
CO_2e Metric tons/MWH	0.00	0.00
LRT CO_2e Metric tons	0.00	0.00

[6] Assuming hypothetical zero net greenhouse gas emission profile for power utilities fully offsetting CO_2 emissions or using carbon-free energy sources.

3.2.4 Commuter Rail VMT

Sounder Commuter Rail VMT is anticipated to be affected by the project. To determine how changes in commuter rail VMT will affect GHG generated within the study area, a quantitative analysis based on fuel usage was conducted. An average rail transit vehicle is estimated to require 92,739 Btu/mile (DOE, Transportation Energy Data Book: Edition 27). By multiplying the commuter rail VMT values under each scenario, the power requirements for each scenario, in terms of overall Btu, were calculated. This estimate was then converted to gallons of diesel fuel required, and a CO_2e emission factor for diesel fuel was applied. The resulting CO_2e pollutant burden is presented in Table 3.6.

Table 3.6 – Annual CO_2e Emission Burdens from Commuter Rail VMT

	No Build 2030	2030 With ST2 Plan
Commuter Rail		
Commuter Rail Daily VMT	7,956	10,063
Commuter (Diesel) Propulsion CO_2e metric tons	54	68

Direct Energy References:
US Department of Energy, Transportation Energy Data Book Edition 27
American Public Transportation Association, 2007 Public Transportation Fact Book
Fuel Consumption for Propulsion of LRT = 92,739 Btu/Vehicle-Mile

3.3 Summary and Discussion of Impacts

Table 3.7 shows the summary of the elements analyzed in determining the GHG emission burdens for the proposed project alternatives.

3.3.1 Roadway GHG emission burdens

As shown in Table 3.7, daily roadway GHG emissions burdens are reduced by 0.87 percent under the Build alternatives in 2030 as compared to the No Build Alternative. Since the speed change between the alternatives is minimal (less than 1 mph), the reduction in GHG emissions reflects the direct reduction in VMT.

3.3.2 Sound Transit Bus GHG emission burdens

As shown in Table 3.7, daily GHG emissions burdens due to Sound Transit buses are predicted to decrease under the build alternatives in 2030 by about 15.85 percent. This decrease in bus emissions is directly related to the predicted decrease in Sound Transit Bus VMT under this alternative. Under this alternative, there is a substantial shift in VMT from bus usage to light rail usage.

3.3.3 Light Rail GHG Emission Burdens

As shown in Table 3.7, daily GHG emissions burdens due to light rail, using the current energy profile of the state, are predicted to increase under the build alternatives in 2030 by about 262 percent, as compared to the No Build Alternative. These increases reflect increased LRT usage under the various build alternatives as compared to the No Build Alternative. As shown in Table 3.7, if the LRT system is assumed to run on net zero GHG power emissions, there is predicted to be no increase in GHG emissions, even though there is a large increase in LRT VMT.

3.3.4 Commuter Rail GHG Emission Burdens

As shown in Table 3.7 daily GHG emissions burdens due to commuter rail are predicted to increase under the build alternatives in 2030 by approximately 26.5 percent, due to an expansion of commuter rail service.

3.3.5 Summary of Overall Results of GHG Analysis

By combining the estimated GHG emission burdens generated by roadway, bus, commuter and light rail, the total overall effect of each of the alternatives on GHG emission burdens can be compared, as shown in Table 3.7. In 2030, the ST2 plan is predicted to reduce overall regional CO_2e emissions by approximately 362 metric tons daily, or 99,552 metric tons annually using current electric power fuel mix assumptions. Under a potential future scenario in which all electricity is generated using non-carbon emitting sources or emissions are offset, the CO_2e emissions reduction is about 585 metric tons daily, or 178,334 metric tons annually. This represents a regional reduction in the GHG emission burden by approximately 0.71 percent under the current energy profile, or by about 1.11 percent under the carbon-free power generation scenario.

This upper estimate of 178,334 metric tons of CO_2e emissions is the equivalent of[7]:

- 414,731 barrels of oil a year,
- 1,244 acres of forest preserved from deforestation a year, or
- 931 railcars' worth of coal a year.

[7] Source: Greenhouse Gas Equivalencies Calculator (http://www.epa.gov/cleanenergy/energy-resources/calculator.html)

Table 3.7 – CO_2e Summary Emission Burden Assuming Current LRT Energy Profile and Carbon Free Electric Profile

Mode	No Build 2030	2030 With ST2 Plan – Current Energy Profile	2030 With ST2 Plan – Carbon Free Energy Profile
Roadways			
Daily Auto VMT	99,398,539	98,536,539	98,536,539
Total Daily CO_2e (Metric tons)	45,485	45,091	45,091
% Change from Baseline	-	-0.87%	-0.87%
Sound Transit Buses			
Daily Bus VMT	50,420	42,427	42,427
Total Daily CO_2e (Metric tons)	125	105	105
% Change from Baseline	-	-15.85%	-15.85%
Other Buses			
Daily Bus VMT	166,497	122,704	122,704
Total Daily CO_2e (Metric tons)	431	318	318
% Change from Baseline	-	-26.30%	-26.30%
LRT			
Daily LRT VMT	25,587	92,587	92,587
Total Daily CO_2e (Metric tons)	71	258	0
% Change from Baseline	-	261.86%	-
Commuter Rail			
Daily Commuter Rail VMT	7,956	10,063	10,063
Total Daily CO_2e (Metric tons)	54	68	68
% Change from Baseline	-	26.48%	26.48%
TOTAL (Roadways, LRT & Commuter Rail, Buses)			
Total Daily CO_2e (Metric tons)	46,166.6	45,840.2	45,581.9
Total Annual CO_2e (Metric tons)	14,080,813	13,981,261	13,902,480
% Change from No Build	-	-0.71%	-1.11%

4. Energy Security Implications

4.1 *Energy Source for ST2*

The Sound Transit light rail system is an electric light rail system, so relies on electric power generation for its energy. According to the U.S. Energy Information Administration, Washington State is the leading hydroelectric power producer in the U.S., and the Grand Coulee hydroelectric power plant on the Columbia River is the highest capacity electric plant in the United States.[8] Table 4.1 indicates fuel sources for the major power utilities in the region.

Table 4.1. – Fuel Mix for Power Generation, 2007[9]

Generation Type	Seattle City Light	Puget Sound Energy	Snohomish County PUD
Hydroelectric	90.61%	45%	81%
Nuclear	4.83%	1%	9%
Wind	3.25%	2%	
Coal	0.85%	34%	6%
Natural Gas	0.37%	17%	2%
Other	0.09%	1%	2%

4.2 *Becoming Rapidly More Dependent on Imported Oil*

Although Washington State does not produce its own crude oil, it is a principal refining center serving Pacific Northwest markets. Our state's five refineries receive crude oil primarily from Alaska. Figure 4.1 below shows U.S. crude oil production as a whole, including Alaskan oil production, while Figure 4.2 shows Alaskan oil specifically, as it is Washington State's major supplier.

As shown in Figures 3.3 and 3.4, because Alaskan production is in decline, the west coast is rapidly becoming increasingly dependant on crude oil imports.[10] These imports are both from OPEC countries, and non-OPEC countries (such as Canada). Oil imports to the west coast of the U.S. have increased from about 14 percent in 1995 to about 47 percent in 2007.[11] This increasing dependence on imported oil presents a number of security risks.

---

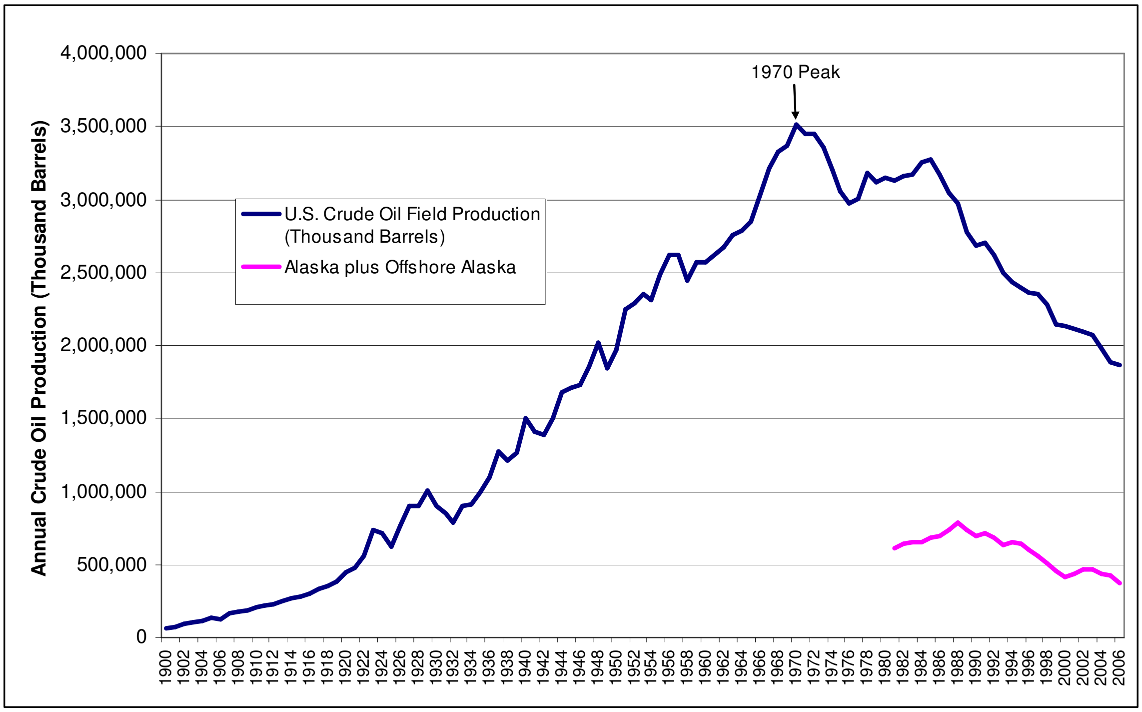
[8] Source: U.S. Energy Information Administration, Washington State Energy Profile.

[9] Source: Seattle City Light, Fuel Mix in 2007, http://www.ci.seattle.wa.us/light/FuelMix/
http://www.pse.com/energyEnvironment/energysupply/Pages/EnergySupply-Electricity-PowerSupplyProfile.aspx;
http://www.snopud.com/energy/pwrsource.ashx?p=1878#fuelmix

[10] Source: U.S. Energy Information Administration, Washington State Energy Profile.

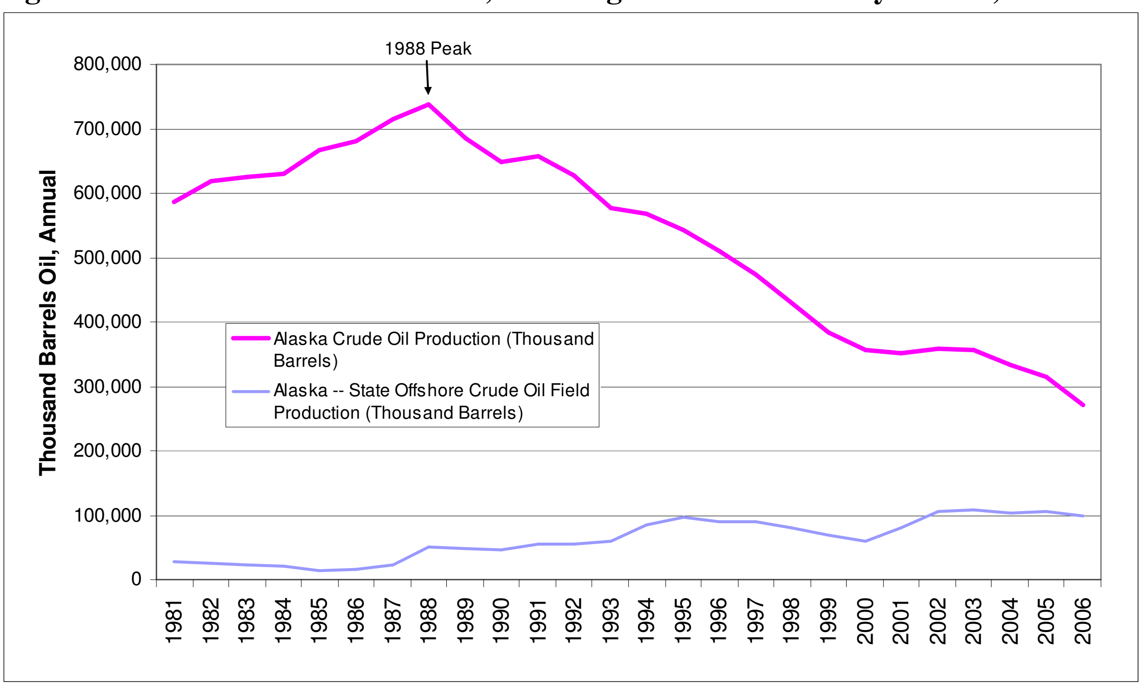
[11] Source: U.S. Department of Energy, Energy Information Administration: West Coast (PADD 5) Crude Oil and Petroleum Products Imports from All Countries (Thousand Barrels); Total Crude Oil and Petroleum Products Product Supplied for PADD 5 (Thousand Barrels). PADD 5 represents West Coast: Alaska, Arizona, California, Hawaii, Nevada, Oregon, and Washington.

Figure 4.1 - U.S. Crude Oil Production Has Been in Decline for Several Decades



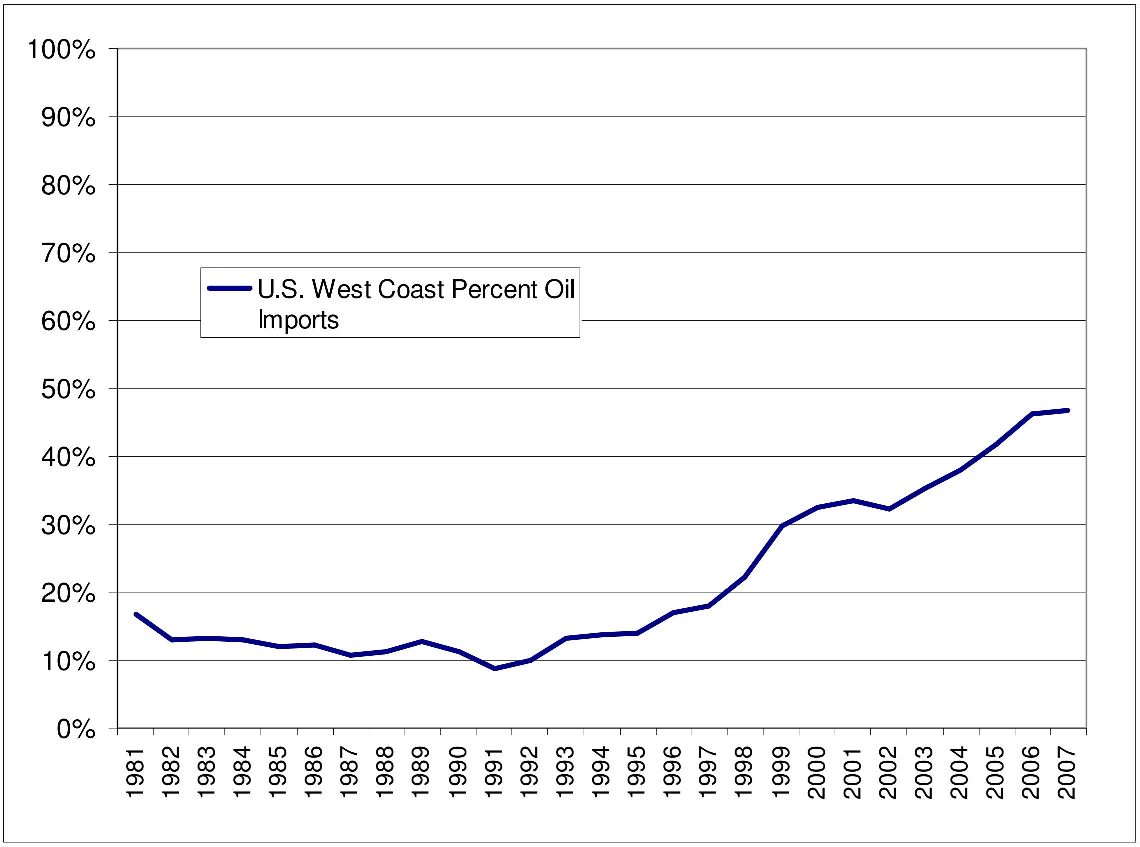
Source: U.S. EIA, Crude Oil Production, Thousand Barrels,
http://tonto.eia.doe.gov/dnav/pet/pet_crd_crpdn_adc_mbbl_a.htm

Figure 4.2 - Alaskan Oil Production, Washington State's Primary Source, is in Decline



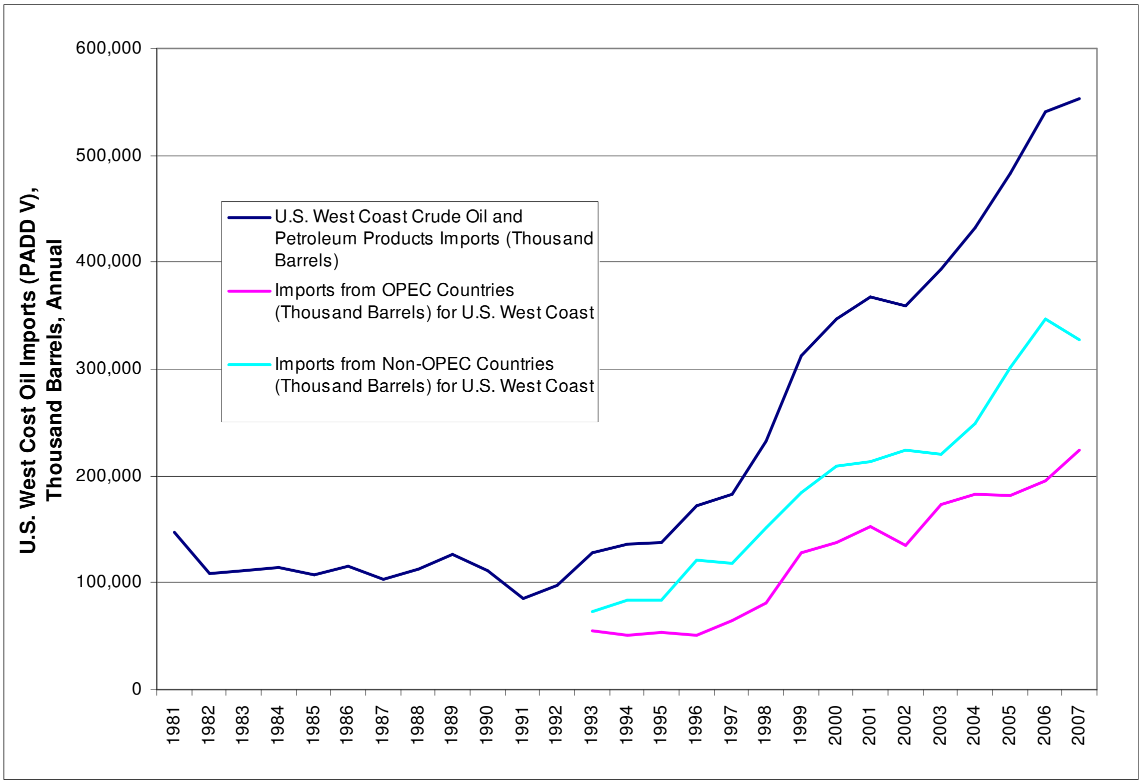
Source: U.S. EIA, Crude Oil Production, Thousand Barrels,
http://tonto.eia.doe.gov/dnav/pet/pet_crd_crpdn_adc_mbbl_a.htm

Figure 4.3 - Oil Imports on the Rise on the West Coast



Source: U.S. Department of Energy, Energy Information Administration: West Coast (PADD 5) Crude Oil and Petroleum Products Imports from All Countries (Thousand Barrels); Total Crude Oil and Petroleum Products Product Supplied for PADD 5 (Thousand Barrels). PADD 5 represents West Coast: Alaska, Arizona, California, Hawaii, Nevada, Oregon, and Washington.

Figure 4.4 -U.S. West Coast Oil Imports, Non-OPEC and OPEC



Source: EIA PAD District Imports by Country of Origin – Total Crude Oil and Products Imports, Annual in Thousand Barrels, West Coast PADD 5.

4.3 Energy Security Risks

Nationally, about 96 percent of the transportation sector depends on petroleum-based fuels for energy[12]. The transportation sector is by far more dependent on petroleum than any other sector of the economy. There are a number of potential risks to this dependency on petroleum for the Puget Sound region, including:

1. Geopolitical disruptions.
2. Inadequate petroleum refining or processing capabilities.
3. Global peak in the production of oil (i.e., peak oil), which would be a long-term disruption in supply.
4. Natural disasters, such as a major earthquake, which could damage the Olympic pipeline, the Trans Mountain Pipeline, or refineries.
5. Coordinated terrorist attacks on critical energy infrastructure in the U.S. or abroad.

Although the U.S. has strategic stockpiles of crude oil, these are not always useful in a supply disruption. For example, the U.S. Strategic Petroleum Reserve (SPR) would not protect the U.S. against a lengthy oil supply disruption. In addition, the SPR may not be particularly helpful for some short-term disruptions either. Commander Bruce L. Peck Jr. of the U.S. Navy prepared a

[12] Source, Transportation Energy Data Book, Edition 26

report titled *The U.S. Strategic Petroleum Reserve - Needed Changes to Counter Today's Threats to Energy Security*. This report describes some limitations of the SPR:

> *"Specifically, the SPR's concentrated location along the Gulf Coast, its inability to directly send oil to all refining areas in the United States, strategic vulnerabilities in its existing distribution pipelines, its size and limited pumping capacity, and the absence of refined fuels as part of the SPR all combine to make the SPR increasingly unable to protect the United States from major disruptions in oil supply."*[13]

A fuel shortage experienced in North Carolina following Hurricane Katrina provides an example.[14] In order for North Carolina to use oil from the SPR in the immediate aftermath of Hurricane Katrina, the oil would have had to be withdrawn from the SPR in a flood damaged area, and processed at a refinery at a time when many refineries near the SPR were damaged by Hurricane Katrina. The refined petroleum products would then have had to be transported to North Carolina. This too would have been problematic since North Carolina receives about 90 percent of its motor fuels through two pipelines (the Colonial and Plantation). Both of these pipelines were temporarily shut down for several days following Hurricane Katrina.

For the U.S. as a whole, pipelines are critical for quickly moving oil and fuel between regions. For example, in the year 2000 pipelines moved virtually all of the crude oil and about 70 percent of the gasoline, diesel, and other refined products.[15] Here on the west coast, the energy infrastructure is logistically separate from the rest of the country, as shown in Figure 4.5.[16]

Because the SPR sites are located along the Gulf Coast, they can not quickly provide oil to Washington State during an oil supply disruption. Washington State is almost entirely dependent on oil delivered via tankers and barges to refineries, and oil from the Trans Mountain Pipeline from Canada. The crude oil pipelines from the Gulf Coast do not transport oil to U.S. refineries on the west coast. Therefore, crude oil would from the SPR would instead have to be transported either via roads in tanker trucks, or via tankers and barges through the Panama Canal.

For the distribution of finished products (gasoline and diesel), Washington State relies on the Olympic pipeline, barges, and trucks. If any of the critical infrastructure is seriously damaged, a fuel supply disruption could occur. The major refined products pipelines (pipelines that transport gasoline and diesel from refineries to local fuel distribution centers) do not transport refined products from Gulf Coast refineries to the northwest. The west coast gasoline/diesel supply/demand balance is fairly tight and the infrastructure provides only limited flexibility to accommodate short-term issues. If there are problems at one or more refineries, or if the refined product pipeline is damaged, there is no quick mechanism for the energy industry to respond.[17]

---

[13] Commander Bruce L. Peck Jr. of the U.S. Navy, The U.S. Strategic Petroleum Reserve Needed Changes to Counter Today's Threats to Energy Security, March 15, 2006, http://www.strategicstudiesinstitute.army.mil/pdffiles/ksil456.pdf

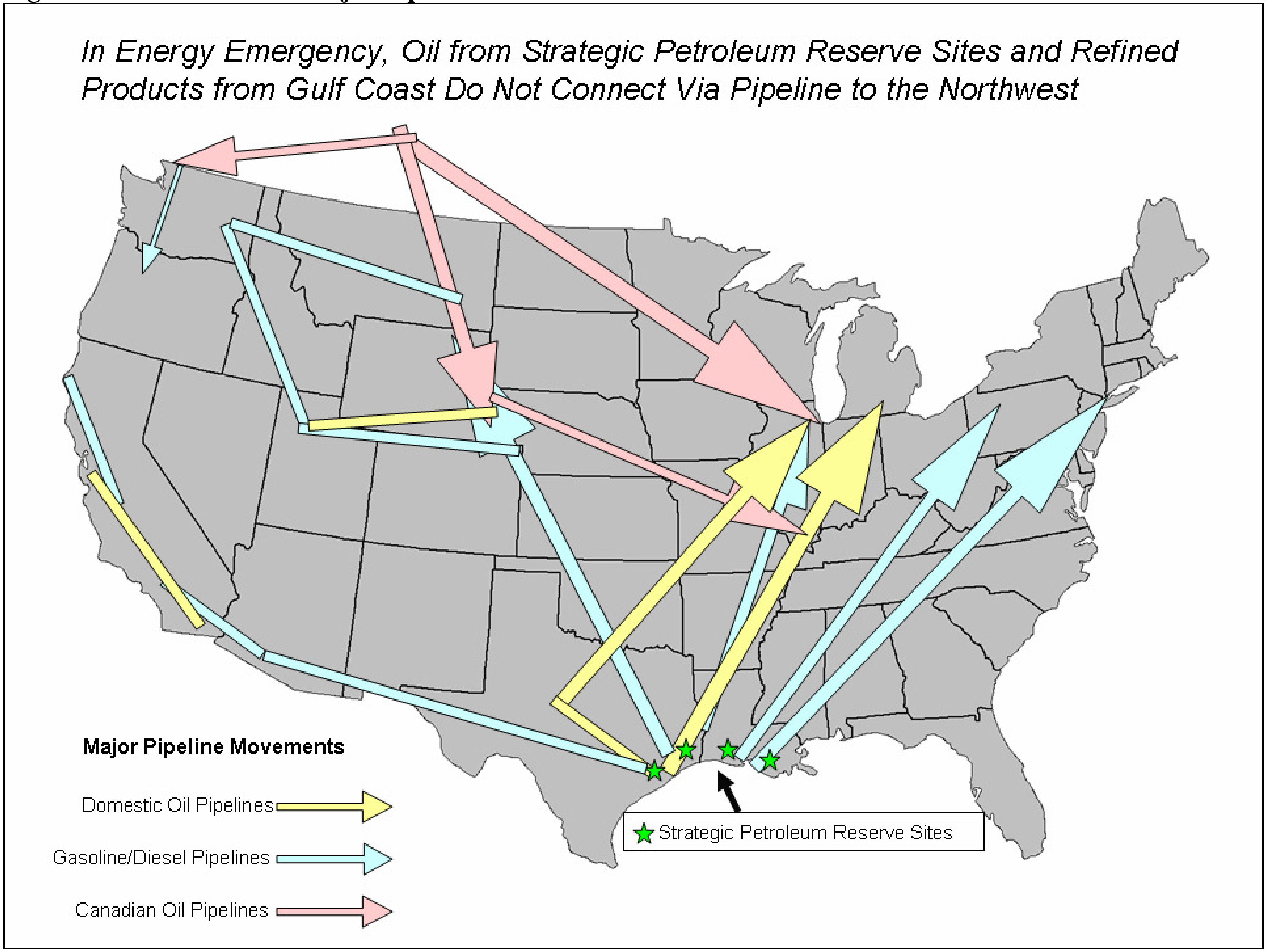
[14] Source: *Implementing the Most Effective Transportation Demand Management (TDM) Strategies to Quickly Reduce Oil Consumption*, January, 2007

[15] Allegro Energy, *How Pipelines Make the Oil Market Work –Their Networks, Operation and Regulation*, Memorandum Prepared for the Association of Oil Pipe Lines And the American Petroleum Institute's Pipeline Committee, December 2001.

[16] Allegro Energy, December 2001.

[17] Source: Richard Rabinow, *The Liquid Pipeline Industry in the United States: Where It's Been, Where It's Going*, A Report prepared for the Association of Oil Pipe Lines, 2004.

Figure 4.5 – Schematic of Major Pipeline Movements



Source of Pipeline Information: Allegro Energy, *How Pipelines Make the Oil Market Work –Their Networks, Operation and Regulation*, Memorandum Prepared for the Association of Oil Pipe Lines And the American Petroleum Institute's Pipeline Committee, December 2001.

4.4 Transit Agency Energy Security Risks

During a fuel supply disruption, a transit agency may face its own fuel shortage. King County Metro has a fuel supply of about two to three days for its fleet of 1,300 buses, and so similar to the general population at large, transit agencies are heavily reliant upon just-in-time delivery.[18] Lack of fuel could provide an additional constraint on the ability of transit providers to increase either peak or off-peak service during an emergency, which was a concern of some transit agencies in North Carolina following fuel supply disruptions there several years ago.[19] In addition, rising fuel prices increase operating costs for transit agencies. These rising costs could require transit agencies to cut service, increase fares, or secure additional operating funds elsewhere.

Washington State has an energy emergency plan, called the Washington State Energy Assurance and Emergency Preparedness Plan. This plan, which is prepared by the Energy Policy Division of the Washington State Department of Community, Trade, and Economic Development (CTED), prepares the state to address energy emergencies, ranging from blackouts to pipeline explosions to petroleum shortages. King County also has a fuel conservation policy that governs procedures the County would follow during a national fuel crisis.[20] This policy was made effective in 1991. This policy statement indicates how fuel for county vehicles will be prioritized during a national fuel crisis and assigns agency roles and responsibilities. However, it is unclear the degree to which these plans and policies will be enable a rapid and effective allocation and prioritization of scarce fuel supplies in a serious emergency. In North Carolina, which also has a state energy contingency plan, some local agencies had difficulty securing fuel when fuel supplies were disrupted after Hurricane Katrina.[21]

Increasing the availability of mass transit service that is not dependent on petroleum can increase the energy security of our transportation systems in the region.

4.5 Gasoline and Diesel Cost Savings from VMT Reductions

Currently, daily vehicle miles traveled (VMT) in the region totals about 81 million.[22] This includes light duty vehicles (passenger cars and trucks), heavy trucks, buses, and motorcycles. Assuming that about 88 percent of VMT is from light duty vehicles (using the vehicle mix indicated in Table 3.1), and the average light duty fleet fuel economy in 2007 was about 20.2

[18] Source: Implementing the Most Effective Transportation Demand Management (TDM) Strategies to Quickly Reduce Oil Consumption, January, 2007

[19] Source: Implementing the Most Effective Transportation Demand Management (TDM) Strategies to Quickly Reduce Oil Consumption, January, 2007

[20] Source: Implementing the Most Effective Transportation Demand Management (TDM) Strategies to Quickly Reduce Oil Consumption, January, 2007

[21] Source: Implementing the Most Effective Transportation Demand Management (TDM) Strategies to Quickly Reduce Oil Consumption, January, 2007

[22] This includes Kitsap County; estimated regional VMT for 2006. Source: Puget Sound Regional Council, Puget Sound Trends, August, 2007.

miles per gallon[23], annual expenditures on diesel and gasoline from light duty vehicles in the region total about $4.7 billion a year at current fuel prices. Because our region does not does not produce any oil, the majority of expenditures on gasoline or diesel are exported to other parts of the country or world.

Regional modeling indicates that the ST2 plan will reduce daily regional VMT by about 862,000. At current gasoline and diesel prices of about $4.35 a gallon for gasoline and $4.93 a gallon for diesel[24], and using the U.S. Energy Information Administration's forecast of light duty fleet fuel economy in 2030, gasoline and diesel savings were estimated. This VMT reduction would result in a regional reduction in gasoline/diesel expenditures of about $41 million per year. Should gasoline and diesel prices continue increasing as they have over the past several years, the savings would be even greater. In addition, because our region does not produce any oil, the majority of expenditures on gasoline or diesel is exported to other parts of the country or world. This contrasts with our power generation, the majority of which is locally produced and therefore most expenditures are recycled back within the state.

4.6 Conclusions from Energy Security Analysis

This analysis has found several energy security benefits that could result from expanding high capacity light rail transit in the region. These include:

- Increased diversification of non-petroleum based energy sources for transportation.
  - The U.S. west coast is rapidly increasing its need for oil imports, as Alaskan oil production declines.
  - There are several security risks due to this dependence on oil, such as geopolitical disruptions, inadequate petroleum refining or processing capabilities, peak oil, natural disasters, or terrorist attacks on critical energy infrastructure.
  - The Puget Sound region may be particularly vulnerable to oil or fuel supply disruptions because the region is not well-connected to domestic energy infrastructure in other areas of the country.
  - High capacity transit that relies on electric power generation will help the region work toward being less dependent on imported oil.
- Retaining more money within the state rather than being exported out of the state or country due to expenditures on oil or fuel.
  - Currently, expenditures on gasoline and diesel for light duty vehicles in the region are estimated at about $4.7 billion a year.
  - Expansion of light rail would reduce VMT in the region, reducing regional gasoline/diesel expenditures by $41 million per year.

[23] Source: U.S. Energy Information Administration 2008 Annual Energy Outlook, fuel economy light duty stock for 2007.
[24] Source, Washington State Department of Community, Trade and Economic Development, Energy Policy Division, Biweekly Energy Status Report, July 11, 2008.

5. Mobility, Land Use, and Other Potential Benefits

The purpose of this section of the report is to build upon the technical GHG analysis described in Section 3 and discuss the following:

- Demographic and economic shifts that are and will continue to increase transit demand in the future;
- The relationship beween LRT service and VMT; and
- Supportive policies that can significantly improve VMT reduction.

The goal is to provide a larger context for the assessment of sustainability, the likely effects that will result from the implementation of the ST2 plan, and the support ST2 can provide for other policies that can further reduce VMT.

5.1 Background

Several structural shifts are changing people's preferences concerning how they travel and where they want to live and work (i.e., travel and location demands). Various trends are increasing the costs of accommodating additional vehicle travel (particularly under urban-peak conditions) and the value of alternative modes. The emerging trends include an aging population, rising fuel prices, increasing traffic congestion, rising construction costs, increasing environmental and health concerns, and changing consumer preferences. The alternative modes that are becoming increasingly valued include walking, cycling, public transit and telework (telecommunications that substitutes for physical travel) and more accessible, multi-modal locations. Meeting these demands benefits consumers directly, and to the degree that it reduces per capita vehicle travel and time spent traveling, it benefits society by reducing problems such as accidents, fossil fuel consumption, and pollution emissions.

Sustainable transportation refers to a transportation system that balances economic, social and environmental objectives. This requires evaluation that takes into account all significant impacts and costs, including those that are indirect and long term. This is a challenge, because it requires more comprehensive analysis than is normally performed, and also an opportunity for more integrated planning that results in more optimal decisions.

Sound Transit can play a key role in defining and implementing a sustainable transportation vision. It currently plays a unique role, providing regional transportation services, which tend to be the most constrained and most costly components of the transportation system, and which must be integrated with local and state transportation programs. By helping to create a more efficient and diverse transport system, Sound Transit provides significant economic, social and environmental benefits.

5.2 Travel Demands Shifts

Travel demand refers to the type and amount of travel activity that people would choose under particular circumstances, taking into account factors such as the prices (for vehicles, fuel, parking, road tolls, transit fares, taxi fares, etc.) and the quality of travel options available. Since land use decisions both affect and are affected by travel demands, they are also likely to change. Table 5.1 summarizes these factors.

Table 5.1 - Trends Affecting Travel Demands

Factor	Travel Impacts	Land Use Impacts
Population aging. The baby boom is reaching retirement age and the elderly portion of the population (over 70 years) is growing. By 2030 PSRC estimates that the population of people 65 and older will increase to 16.8% of the total population. Up from 10.7% in 2010.	As people retire they tend to drive less, particularly during peak periods, and eventually their ability to drive declines and demand for alternative modes increases. People 55-64 tend to drive about 20% less than those 20-55, while people older than 65 tend to drive 50% less. Source: FHWA	Many older people are moving to smaller homes and more accessible, walkable neighborhoods with good transit service.
Rising fuel prices. Fuel prices have increased substantially in recent years and are likely to stay high in the future.	Per capita vehicle travel is declining for the first time in decades. Motorists are choosing more efficient vehicles. Demand for alternative modes is increasing.	Demand for more accessible and transit-oriented development is increasing.
Environmental concerns. Many jurisdictions, including Seattle and Washington State, have targets to reduce emissions and loss of greenspace.	These goals and objectives justify polices, planning practices, and personal behavior changes that reduce motor vehicle travel and encourage use of alternative modes.	These goals and objectives justify polices and planning practices to create more accessible, multi-modal communities.
Increased congestion. Many roads and parking facilities have become congested, and capacity expansion costs are increasing.	Congestion limits urban-peak driving distances, and increases demand for alternative modes, particularly grade-separated public transit and telework.	Congestion discourages longer-distance commuting and dispersed land use development.
Increase urbanization. An increasing portion of the population lives in urban areas.	Urban residents drive less and rely more on alternative modes, including walking, cycling, public transit.	More people are choosing urban locations and suburban communities are urbanizing.
Health concerns. Health officials and consumers increasingly recognize the health value of reduced driving and increased walking and cycling.	Increases demand for walking and cycling facilities, and may result in conflicts among users.	Increases demand for walkable and bikeable communities, and transit-oriented development.
Changing preferences. Driving and suburban living are less glamorized, and alternative modes and urban living less stigmatized.	Many consumers will consider transportation alternatives, such as walking, cycling, public transit and telework.	Many consumers will consider housing alternatives, such as small-lot homes, townhouses, condominiums, etc.
Service quality. Consumers are accustomed high quality services and technologies.	People expect transportation services to respond to their needs and preferences, and will pay a premium.	Consumers will pay to live in communities with features such as walkability and quality transit.
New technologies. New technologies can provide information and automation.	New devices can provide travel information, navigation and automated fee payments.	Multi-modal locations become more accessible.

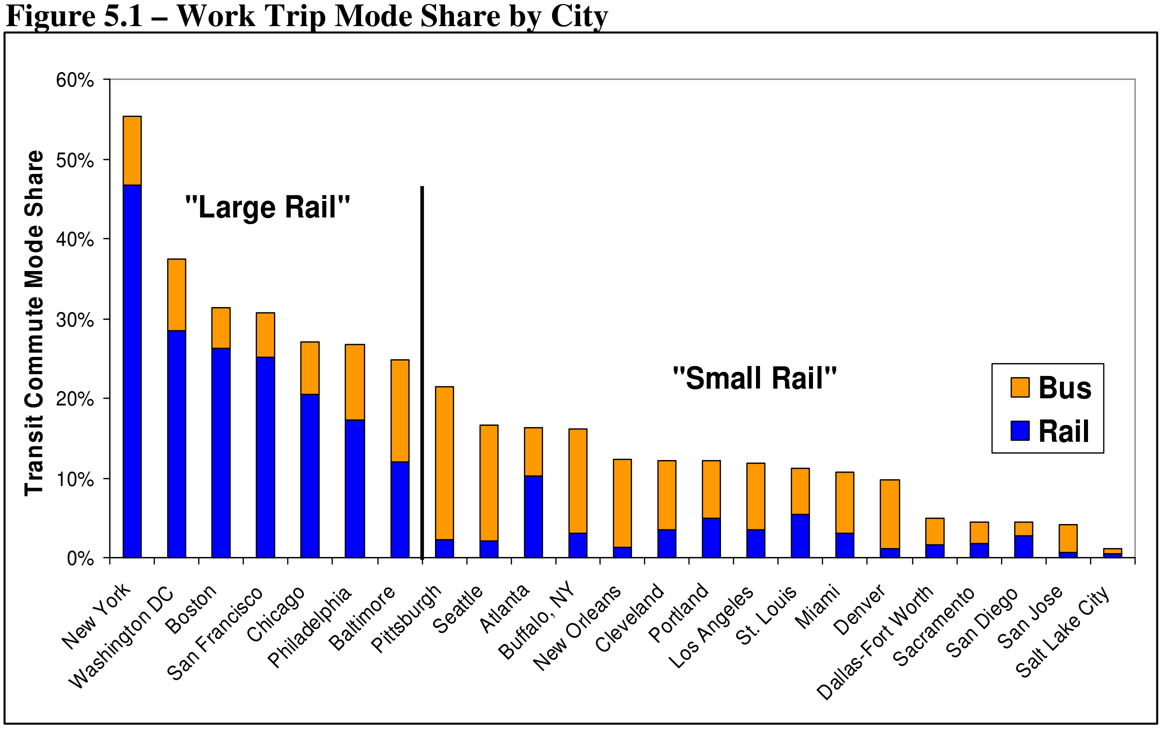
Virtually all of these shifts increase demand for alternative modes, particularly among discretionary travelers, that is, people who *could* use an automobile. This does not mean automobile travel will disappear, but it does highlight the need for providing alternative modes as the patterns of activity affecting travel behavior shifts over time.

5.3 Relationship between Transit, VMT and Supportive Strategies

One critical component in the evaluation of greenhouse gas emissions is the reduction in vehicle miles traveled. Section 3 of this sustainability assessment describes the traditional approach used for ST2 that made use of the ST2 travel forecasting model in conjunction with standard air quality methodologies and tools. However, it is also worthwhile to look outside the Sound Transit experience to other locations to see what types of additional VMT reductions could be achieved if supportive policies were enacted to supplement the rail expansion included in ST2.

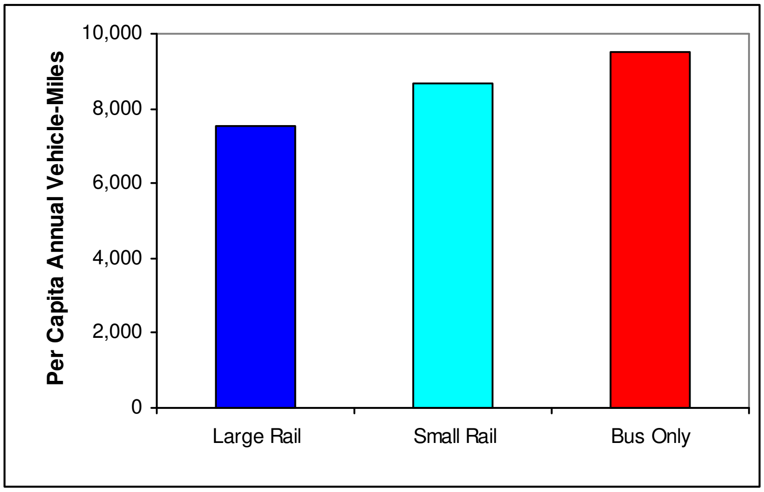
Research shows generally that regional VMT in cities with mature rail systems tend to be higher than for those cities without mature rail systems. The following two figures (Figures 5.1 and 5.2) were taken from the *Rail Transit In Americ*a study by the Victoria Transport Policy Institute and show the mode share and resulting average VMT per capita for cities with varying levels of rail transit.

Figure 5.1 – Work Trip Mode Share by City



Source: Litman, Todd, Victoria Transport Policy Institute, *Rail Transit In America, A Comprehensive Evaluation of Benefits,* 2006.

Figure 5.2 - Per Capita Annual Vehicle Miles Traveled (VMT)



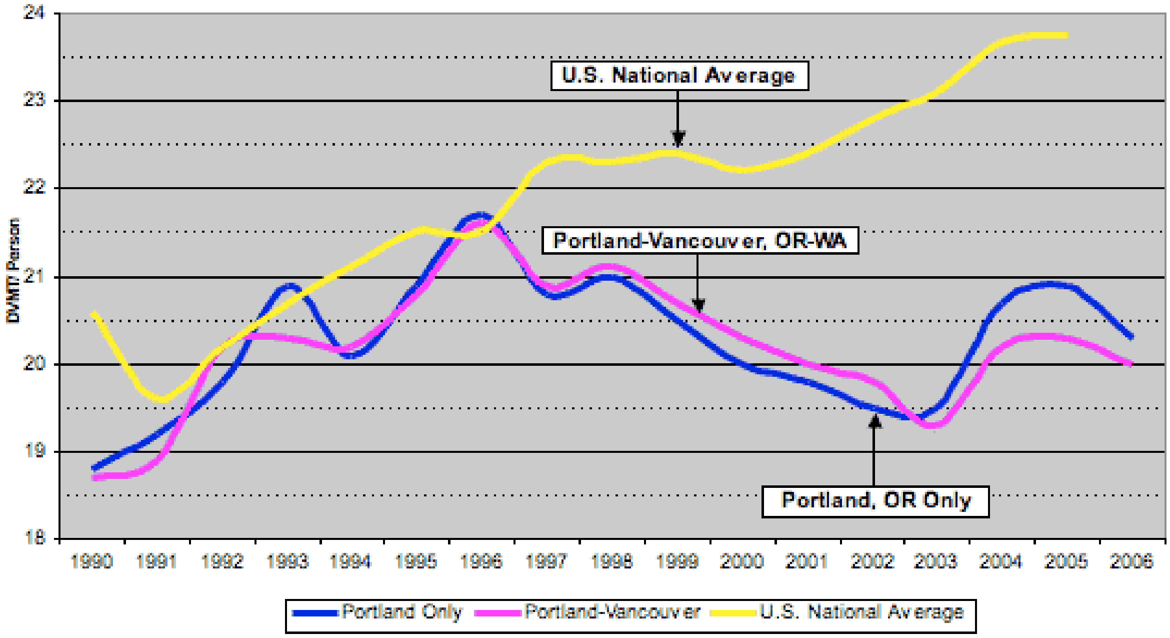
Source: Litman, Todd, Victoria Transport Policy Institute, *Rail Transit In America, A Comprehensive Evaluation of Benefits,* 2006.

A more detailed investigation of the Portland Metro area with respect to VMT provides an example of the level of impact that can be achieved in VMT reduction when a number of factors are at work concurrently. Figure 5.3 compares Portland's VMT per capita to the national average with Portland generally averaging about 10-15 percent lower VMT than the nation. While a number of factors have contributed to Portland's low VMT per capita, two of the more critical elements are the provision of high quality transit service (44 miles of LRT, downtown streetcar, local and feeder bus) and effective land use controls.

The urban growth boundary has resulted in 30 percent of all regional jobs being located within 3 miles of the Portland Central Business District (CBD). This level of employment density is 3rd in the nation for large metropolitan areas (Glaeser, Kahn, et al, 2001). Likewise the implementation of the urban growth boundary has resulted in increased population density. A study of the travel patterns of people living in Portland showed people in the most urbanized neighborhoods tend to travel only a third as many miles as those in the least urbanized neighborhoods (Lawton 2001).

Currently, Seattle area residents average 23.0 daily vehicle-miles traveled, compared with 17.1 in New York, 19.9 in Portland, and 23.0 in Los Angeles. (FHWA's Highway Statistics 2006 report (www.fhwa.dot.gov/policy/ohim/hs06/xls/hm72.xls).

Figure 5.3 - Portland's Vehicle Travel Trends



Source: Metro, Daily vehicle miles of travel (DVMT)/person for Portland and the US, Oregon Metro (www.oregonmetro.gov), 2008; at www.oregonmetro.gov/index.cfm/go/by.web/id=26796.

5.4 Transportation Improvement Strategies

There are many possible ways to improve transportation services and encourage use of efficient modes. Some of these are already being implemented in the Puget Sound region. Below are examples:

- Improve Transit Service
  - More types of public transportation services (rail, express bus, conventional urban bus, demand responsive bus, vanpooling, carsharing, vansharing, and taxis).
  - More service (more routes, time and frequency).
  - Faster service (including grade separation and improved operations).
  - Service that provides more reliable arrival times at destinations (exclusive rights-of-way)
  - Reduced crowding.
  - More comfortable vehicles, including smoother ride, larger seats, cupholders, onboard WiFi, reading lamps and worktables.
  - Ability to serve more people (high capacity transit)

- Improved transit stations and stops.
  - Nicer station buildings and shelters.
  - Reduced crowding.
  - Improved station services and amenities, such as refreshments, washrooms, vendors, WiFi, etc.
  - Improved security.

    - Improved wayfinding.

- Reduced fares and targeted discounts
    - Lower rates for off-peak travel times.
    - Discounts for targeted groups, such as frequent users, students and seniors, so a larger portion of the population has prepaid transit passes.
- More convenient payment systems, such as easy-to-use ticket machines (which accept coins, bills, credit and debit cards), electronic "smart cards," and transit passes provided to groups of students, employees and residents.
- Commute trip reduction programs that encourage use of alternative modes for commute trips, with features such as parking cash out, flextime and telework.
- Improved rider information (such as route, schedule and fare information, and real time bus and train arrival information, easily available by mobile telephone and displays at stations and stops) and direct marketing programs (which encourage residents to try efficient modes).
- Park-and-ride facilities and promotion programs.
- Parking and road pricing, and pay-as-you-drive vehicle insurance (where a portion of auto insurance premiums are linked to miles driven).
- Improve walking and cycling conditions.

Many of these strategies can significantly increase transit ridership. For example, worksites with commute trip reduction programs that include parking pricing or parking cash out programs typically have 10 to 30 percent less automobile commuting and 50 to 200 percent greater transit commuting, depending on conditions. Similarly, people who live or work in transit-oriented development tend to own 5 to 20 percent fewer cars and drive 20 to 40 percent less than residents of more automobile-oriented developments.

Many of these strategies are synergistic (total impacts are greater than the sum of their individual impacts). For example, improving public transit service or parking pricing by themselves may each only reduce automobile travel by 5 percent, but if implemented together they may reduce total automobile travel by 15 percent, because they give travelers both the option and the incentive to shift mode.

Table 5.2 summarizes the travel impacts of various mobility management (also known as transportation demand management) strategies. Different strategies affect different portions of total vehicle travel. For example, commute trip reduction programs only affect commute travel, which represents about 20 percent of total vehicle travel, so a program that reduces average commute trips by an average of 20 percent that is implemented at 50 percent of worksites will reduce total travel by about 1 percent (20 percent of travel x 20 percent reduction x 50 percent of worksite = 1 percent). The appendix shows a VMT reduction analysis framework that could be used with program implementation partners to assess the potential impact of various strategies on regional VMT. The expected impact of various strategies would depend on the program design and implementation.

Some strategies may affect all personal travel or all vehicle travel, such as pay-as-you-drive (PAYD) vehicle insurance and registration pricing, and fuel tax increases. Some strategies are particularly effective at achieving a particular objective. For example, congestion pricing can provide proportionately large congestion reductions, fuel tax increases can provide proportionately large energy conservation and emission reductions, and PAYD insurance can provide proportionately large crash reductions compared with their reductions in VMT. A recent study that evaluates potential vehicle travel and emission impacts of mobility management strategies in the Vancouver, British Columbia region (Litman, 2004) represents a model that can be applied in Western Washington. This model is shown in the Appendix.

Table 5.2 – Potential Travel Impacts of Transport Demand Management Strategies

Strategy	Description	Type of Travel Affected	Typical Reduction in Affected VMT[25]
Transit service improvements	Significantly increase routes, frequency, comfort, convenience, and station quality.	Local urban travel	5-15%
Transit fare reductions	Reduce transit fares, offer discounts, encourage bulk pass purchases, offer off-peak discounts.	Local urban personal travel	2-5%
Ridesharing programs	Rideshare matching, vanpool development.	Commuting	2-5%
HOV priority	Provide dedicated HOV or transit lanes and other priority features	Local urban personal travel (particularly commuting)	5-10%
Walking and Cycling Improvements	Improve walking and cycling conditions in a community.	Local travel. Also important for transit.	5-15%
Parking pricing and management	Charge motorists directly and efficiently for using parking facilities, cash out and unbundle parking.	All personal travel	10-30%
PAYD pricing	Charge insurance and registration fees by the vehicle-mile rather than the vehicle-year	All personal travel	5-10%
Road pricing	Charge tolls for driving on specific roads, with higher fees during congested conditions	All travel	10-30%
Fuel price increases	Increase fuel taxes. Can be revenue-neutral shift.	All travel	5-15%
Commute Trip Reduction	Businesses to encourage use of alternative commute modes, including flextime and telework.	Commuting	10-30%
Freight transport management	Develop programs to increase fright transport system efficiency	Freight transport	5-15%
User information	Provide convenient information on routes, schedules, fares and navigation.	Personal travel	Varies
Mobility management marketing	Use direct marketing to promote use of alternative modes and provide user information.	All personal travel	5-15%
Smart growth	Encourage more compact, mixed, multi-modal development to allow more parking sharing and use of alternative modes.	All travel	10-30%
Transportation management associations	Establish member-controlled organizations that provide transport and parking management services in a particular area.	All travel to that area	Varies

Many of these strategies reflect market principles. An efficient market requires that consumers have diverse goods and services to choose from, cost-based pricing, and economic neutrality (public policies do not arbitrarily favor a particular good or group). For example, walking,

[25] Estimating impacts requires application of model in the Appendix.

cycling and public transit improvements increase consumer mobility options; road, parking and insurance pricing better reflect costs; and many parking and smart growth policy reforms reflect economic neutrality by removing current biases favoring automobile travel and sprawl.

5.5 Sound Transit Supportive Programs

The ST2 plan includes various service improvements to accommodate demand growth, and some incentive programs to encourage shifts to efficient modes. However, it is worthwhile to consider additional improvements and incentives in response to shifting demands (due to rising fuel prices and urbanization) and additional planning objectives (such as accommodating the replacement of the Alaskan Way Viaduct, and emission reduction targets). Table 5.3 identifies examples of integrated service enhancement programs that should be evaluated in terms of impacts, benefits and cost effectiveness. Many of these are programs that would be implemented by agencies other than Sound Transit.

Table 5.3 - Transportation Service Enhancement Programs

Enhancement	Moderate Enhancements	Major Enhancements
Transit service improvements	50% more service	100% more service
Transit fare reductions	20% fare reductions	50% fare reductions
Ridesharing programs	20% vanpool subsidies	50% vanpool subsidies
HOV/Transit priority	100 more HOV lane-miles	200 more HOV lane-miles
Walking and Cycling Improvements	$50 million annual expenditures	$100 million annual expenditures
Parking pricing and management	Double portion of parking that is priced	Quadruple portion of parking that is priced
PAYD pricing	Optional PAYD insurance available to all	Universal PAYD insurance & reg. fees
Road pricing	Congestion pricing on major highways	Congestion pricing on all major urban roads
Fuel price increases	5% annual tax increase	10% annual tax increase
Commute Trip Reduction	CTR for 40% of employees	CTR for 60% of employees
Freight transport management	Affects 20% of regional freight activity	Affects 50% of regional freight activity
Mobility management marketing	Contacts every household bi-annually	Contacts every household annually
Smart growth	50% of new development in transit-oriented communities	80% of new development in transit-oriented communities
Transportation management associations	Serving 40% of worksites	Serving 60% of worksites

Additional modeling could estimate the maximum increases in transit ridership and reductions in total vehicle travel that could reasonably be achieved with policies and programs that are considered cost effective, taking into account all costs and benefits (congestion reductions, road and parking facility cost savings, consumer savings and benefits, accident reductions, etc.). This can be based on examples of individual strategies, as well as analysis of cumulative impacts of comprehensive programs in other regions that have more transit-oriented transportation systems and land use patterns.

Many mobility management strategies require action or support by other levels of government, or organizations, as summarized in Table 5.4. This suggests that Sound Transit will need to build partnerships and provide leadership to implement this vision.

Table 5.4 - Transportation Enhancement - Implementation Responsibilities

Enhancement	Local	Regional	State/Federal	Businesses
Transit service improvements	Improve local services	Improve regional services (expanded light rail system, higher service levels on commuter rail and express bus systems)	Provide more funding options	
Transit fare reductions	Increase funding	Increase funding	Provide more funding	
Ridesharing programs		Implement		Provide support
HOV/Transit priority	Shift surface street lanes	Shift highway lanes	Shift highway lanes	
Walking and Cycling Improvements	Improve local facilities and increase funding	Improve regional facilities. Increase funding	Increase funding	Provide support
Parking pricing and management	Implement at municipal parking and change zoning codes	Provide incentives and support.	Provide incentives, such as a per-space parking tax option.	Implement at commercial buildings
PAYD pricing			Change insurance regulations	
Road pricing	Implement in cities	Implement on regional highways.	Provide supporting legislation. Implement on state highways.	
Fuel price increases	Apply local option fuel taxes	Apply regional fuel taxes	Implement gradually increasing carbon or fuel tax.	
Commute Trip Reduction	Require and encourage	Require and encourage	Require and encourage	Implement
Freight transport management	Require and encourage. Provide supportive services.	Require and encourage. Provide supportive services.	Require and encourage. Provide supportive services.	Implement
Mobility management marketing		Implement, or support action by others.		
Smart growth	Require and encourage. Provide supportive services.	Require and encourage. Provide supportive services.	Require and encourage. Provide supportive services.	Implement, and apply to location decisions.
Transportation management associations	Require and encourage.	Require and encourage.		Support and participate.

This table indicates the organization responsible for implementing transportation enhancements.

6. References

Eric de Place (2008), *Vehicle Miles Unraveled*, Sightline Institute (http://daily.sightline.org/daily_score/archive/2008/04/24/vehicle-miles-unraveled)

FHWA (2006), Highway Statistics, Federal Highway Administration (www.fhwa.dot.gov).

John Holtzclaw (2000), *Does A Mile In A Car Equal A Mile On A Train? Exploring Public Transit's Effectiveness In Reducing Driving*, The Sierra Club, (www.sierraclub.org/sprawl/articles/reducedriving.asp).

Keith T. Lawton (2001), The Urban Structure and Personal Travel: an Analysis of Portland, Oregon Data and Some National and International Data, E-Vision 2000 Conference (www.rand.org/scitech/stpi/Evision/Supplement/lawton.pdf).

Kathy Leotta (2007), *Implementing the Most Effective Transportation Demand Management (TDM) Strategies to Quickly Reduce Oil Consumption*, Parsons Brinckerhoff, at http://postcarboncities.net/files/Leotta_ImplementingTDMtoQuicklyReduceOilConsumption.pdf.

Todd Litman (2004), *Evaluating Mobility Management Strategies for Reducing Transportation Emissions in the Fraser River Basin*, Environment Canada; at www.vtpi.org/ec_mm.pdf, and analysis spreadsheet at www.vtpi.org/ec_mm.xls.

Todd Litman (2006a), *Transportation Cost and Benefit Analysis; Techniques, Estimates and Implications*, Victoria Transport Policy Institute (www.vtpi.org/tca).

Todd Litman (2007a), *Evaluating Public Transit Benefits and Costs*, VTPI (www.vtpi.org); at www.vtpi.org/tranben.pdf .

Todd Litman (2007b), *Guide to Calculating Mobility Management Benefits*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/tdmben.pdf.

Todd Litman (2007c), *Build for Comfort, Not Just Speed: Valuing Service Quality Impacts In Transport Planning*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/quality.pdf.

Todd Litman (2008a), *Transportation Elasticities: How Prices and Other Factors Affect Travel Behavior*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/elasticities.pdf.

Todd Litman (2008b), *Land Use Impacts On Transport: How Land Use Factors Affect Travel Behavior,* VTPI (www.vtpi.org); at www.vtpi.org/landtravel.pdf.

METRO (2008), Daily vehicle miles of travel (DVMT)/person for Portland and the US, Oregon Metro (www.oregonmetro.gov); at www.oregonmetro.gov/index.cfm/go/by.web/id=26796.

Commander Bruce L. Peck Jr. of the U.S. Navy, (2006), "The U.S. Strategic Petroleum Reserve Needed Changes to Counter Today's Threats to Energy Security," March 15, 2006, at http://www.strategicstudiesinstitute.army.mil/pdffiles/ksil456.pdf.

PSRC (2008), *Destination 2030*, Puget Sound Regional Council (www.psrc.org/projects/mtp).

United States Department of Energy, Energy Information Administration (EIA), Washington State Energy Profile. http://tonto.eia.doe.gov/state/state_energy_profiles.cfm?sid=WA

United States Department of Energy, EIA, PADD 5 Crude Oil and Petroleum Products Imports from All Countries (Thousand Barrels); Total Crude Oil and Petroleum Products Product Supplied for PADD 5 (Thousand Barrels). http://tonto.eia.doe.gov/dnav/pet/pet_crd_top.asp and http://tonto.eia.doe.gov/dnav/pet/pet_cons_top.asp

VTPI (2008), *Online TDM Encyclopedia*, Victoria Transport Policy Institute (www.vtpi.org/tdm).

Washington State Department of Community, Trade and Economic Development, Energy Policy Division (2008), "Biweekly Energy Status Report, July 11, 2008".

WSDOT (2006), *Washington State Transportation Plan*, Washington State Department of Transportation (www.wsdot.wa.gov/planning/wtp).

7. Appendix – VMT Reduction Estimation Framework

Table 7.1 presents an example of a framework that could be used with partnering agencies to help evaluate various strategies that could be implemented in conjunction with ST2 to provide further benefits. The partner agencies would work with Sound Transit to identify the scale of the programs in order to estimate potential impacts, such as VMT reductions possible from the implementation of various strategies. As described previously, many of these strategies require leadership, action, or support from other agencies, jurisdictions, or organizations.

Table 7.1 – Example of Collaborative Framework to Estimate Potential VMT Reductions from Various Strategies

Strategy	Sector	Sector Energy	Sector Growth		Impacts		Baseline	5-year	10-year	15-year	20-year	Total Savings
			Baseline Sector Annual Energy Growth Rate	Mileage Reduction by Participants	Energy savings by participants	Emission Reduction by participants	First year takeup rate.	Projected portion of sector participatin				Total Annual Energy Savings
MM Programs & Institutional Reforms	Total	100%	1.5%	10%	10%	10%	10%	20%	30%	40%	50%	**3.6%**
Employee Trip Reduction Programs	Commuting	18%	1.5%	20%	20%	20%	10%	25%	40%	55%	70%	**1.7%**
School & Campus Transport Management	School & Campus Travel	3%	1.5%	15%	15%	15%	30%	40%	50%	60%	70%	**0.3%**
Tourist & Special Event Transport Mgt.	Tourist Travel	5%	2.0%	15%	15%	15%	20%	30%	40%	50%	60%	**0.4%**
Freight Transport Management	Freight/Commercial	15%	2.0%	10%	20%	20%	10%	25%	40%	55%	70%	**1.5%**
Aviation Transport Management	Air Travel	2%	2.5%	5%	15%	15%	10%	20%	30%	40%	50%	**0.1%**
Transportation Management Association	Commuters to Major Commercial Centers	5%	1.5%	20%	20%	20%	10%	25%	40%	55%	70%	**0.5%**
Commuter Financial Incentives	Commuting	18%	1.5%	15%	15%	15%	5%	15%	30%	45%	60%	**1.0%**
Distance-Based Pricing	Road Vehicles	85%	1.5%	9%	9%	9%	0%	100%	100%	100%	100%	**8.1%**
Distance-Based Emission Fees	Road Vehicles	85%	1.5%	2%	4%	15%	0%	100%	100%	100%	100%	**3.6%**
Optional PAYD Insurance	Personal Vehicle Travel	80%	1.5%	2.5%	2.5%	2.5%	0%	50%	100%	100%	100%	**1.8%**
Mandatory PAYD Insurance	Personal Vehicle Travel	80%	1.5%	10%	10%	10%	0%	100%	100%	100%	100%	**8.5%**
Fuel Tax Increases	Road Vehicles	85%	1.5%	3%	7%	5%	0%	100%	100%	100%	100%	**6.3%**
Road Pricing	Congested Roads	20%	2.0%	20%	25%	25%	0%	10%	20%	30%	40%	**1.3%**
Parking Pricing	Personal Vehicle Travel	80%	1.5%	20%	20%	20%	10%	20%	30%	40%	50%	**5.7%**
Mobility Management Marketing	Personal Vehicle Travel	80%	1.5%	7%	7%	7%	0%	100%	100%	100%	100%	**5.9%**
Transit Improvements and Incentives	Urban Commuting	10%	1.5%	10%	10%	10%	10%	20%	30%	40%	50%	**0.4%**
High Occupant Vehicle (HOV) Priority	Urban Commuting	10%	1.5%	10%	10%	10%	2%	10%	15%	20%	25%	**0.2%**
Ridesharing	Commuting	18%	1.5%	7%	7%	7%	20%	40%	60%	70%	80%	**0.8%**
Nonmotorized Improvements & Encouragement	Personal trips Under 5 Kilometres	5%	1.5%	10%	10%	10%	20%	35%	50%	60%	70%	**0.3%**
Telework/Flextime	Commuting	18%	1.5%	7%	7%	7%	20%	40%	50%	60%	70%	**0.7%**
Land Use Management Strategies	Road Vehicles	85%	1.5%	20%	20%	20%	20%	30%	40%	50%	60%	**7.7%**
Carsharing and vehicle rentals	Personal Vehicle Travel	80%	2%	40%	40%	40%	1%	2%	3%	4%	5%	**1.1%**
Car-Free Planning and Vehicle Restrictions	Local Street Travel	4%	1.0%	10%	10%	10%	0%	4%	6%	8%	10%	**0.0%**
Traffic Calming	Local Street Travel	4%	1.0%	5%	5%	5%	10%	20%	30%	40%	50%	**0.1%**
Traffic Speed Reductions	Road Vehicles	85%	1.5%	2%	4%	4%	10%	50%	75%	100%	100%	**2.9%**